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EXAMINER	
SAXENA, AKASH	
ART UNIT	**PAPER NUMBER**
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NOTIFICATION DATE	DELIVERY MODE
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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

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Office Action Summary	Application No. 10/809,276	Applicant(s) CENTALA ET AL.	
	Examiner AKASH SAXENA	Art Unit 2128	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *06 August 2010*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *2-9,11-23,26-38,40,45 and 46* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *2-9,11-23,26-38,40,45 and 46* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application

6) ☐ Other: _____.

Comment [a1]: Added New Reference Chen and updates are in Brown.

DETAILED ACTION

1. Claims 2-9, 11-23, 26-38, 40, and 45-46 have been presented for examination based on applicant's amendment of 08/06/2010.
2. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 08/06/2010 has been entered.
3. Claims 2-9, 11-23, 26-38, 40, and 45-46 are newly rejected under 35 USC 103.
4. This action is made Non-Final.

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Response to Declaration filed under 1.132

5. Regarding Items 1-5: Declarant has a vested interest in the outcome. MPEP 716.01(c) III states:

> In assessing the probative value of an expert opinion, the examiner must consider the nature of the matter sought to be established, the strength of any opposing evidence, the interest of the expert in the outcome of the case, and the presence or absence of factual support for the expert's opinion

6. Regarding Items 6-8 are noted.
7. Regarding Items 9: Applicant has stated Amoco program is static as per declaration ... however nothing dynamic is claimed in independent claim 45 & 46. MPEP 2143.02 (Reasonable Expectation of Success Is Required) requires reasonable expectation of success; applicant has only provided speculation and no evidence.
8. Regarding Item 10: Applicant has alleged that Warren and Glass generally (not all the time) provide single numeric answer. First as admitted by applicant this is not the case every time and secondly, how this is related to the patentability of instant claims is not conveyed.
9. Regarding Item 11: First, in response to applicant's argument that the references fail to show certain features of applicant's invention, it is noted that the features upon which applicant relies (i.e., dynamic model/simulation) are not recited in the rejected claim(s). Although the claims are interpreted in light of the specification, limitations from the specification are not read into the claims. See *In re Van Geuns*, 988 F.2d 1181, 26 USPQ2d 1057 (Fed. Cir. 1993).Secondly, even if claimed what makes the model/simulation dynamic is neither claimed nor the applicant has provided any evidence from specification or otherwise what it constitutes. Mere allegation the combination of Glass and Warren are static is not sufficient without evidence.

10. Regarding Items 12: Glass teaches use of preselected number of revolutions (See Fig.3A-B, 4A-C) where the each revolution is a simulation quantum with maximum number of quantums executed by the analytical model (Glass: Col.5 Lines 7-11; 24-64). Applicant has stated in the remarks Pg.4-6 dated 12/16/2009:

> Contrary to the Examiner's assertion, <u>there is no teaching or suggestion that the particular timeframe shown in Figure 3A is comparable to a **preselected time**.</u> Rather, Figure 3A and its associated text teaches only that a simulation is run, <u>during which time necessarily passes</u>. By asserting that a preselected time is the same as a certain amount of time passing, the Examiner is removing this element from the context of the claims. Independent claims 45 and 46 require, in part, methods that include a step of adjusting a parameter to determine when a variable (e.g., the magnitude of the radial forces) is less than a predetermined value <u>for that preselected time</u>. <u>**Glass merely teaches that an iteration is run for a particular time**</u> **[1]**.

It is unclear how the <u>preselected time</u> is not <u>**iteration [is] run for a particular time**</u> (See [1]). Applicant has not provided any evidence that Glass does not teach this "preselected time" and in view of [1] has buttressed examiner's response.

Applicant has not met their burden under MPEP 716.02(e) which states:

> 716.02(e) [R-2] Comparison With Closest Prior Art
> <u>An affidavit or declaration under 37 CFR 1.132 must compare the claimed subject matter with the closest prior art to be effective to rebut a prima facie case of obviousness</u>. In re Burckel, 592 F.2d 1175, 201 USPQ 67 (CCPA 1979). "A comparison of the claimed invention with the disclosure of each cited reference to determine the number of claim limitations in common with each reference, bearing in mind the relative importance of particular limitations, will usually yield the closest single prior art reference." In re Merchant, 575 F.2d 865, 868, 197 USPQ 785, 787 (CCPA 1978) (emphasis in original). <u>**Where the comparison is not identical with the reference disclosure, deviations therefrom should be explained**</u>, In re Finley, 174 F.2d 130, 81 USPQ 383 (CCPA 1949), <u>and if not explained should be noted and evaluated, and if significant, explanation should be required</u>. In re Armstrong, 280 F.2d 132, 126 USPQ 281 (CCPA 1960) (deviations from example were inconsequential).

Nonetheless, the rejected is further updated to include a specific recitation of preselected time. For at least the above reasons the declaration is not effective.

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Response to Claim Rejections - 35 USC § 103

(Argument 1) Applicant has argued in Remarks (8/6/2010) Pg.2:

> Please find submitted herewith an Expert Declaration of Mike Azar ("Azar Declaration"), which is submitted pursuant to 37 C.F.R. § 1.132. The Azar Declaration is submitted as evidentiary support of the arguments submitted August 5, 2010, in response to the final Office Action, dated April 5, 2010. Specifically, the Azar Declaration details that SPE article "Drag-Bit Performance Modeling" ("Warren") and U.S. Patent No. 6,695,073 ("Glass"), when referring to drill bit simulation program, are referring to the Amoco Program.
>
> The Azar Declaration further indicates that Warren, Glass, and the Amoco Program do not disclose time, much less a pre-selected time, as a variable in simulated drilling. Furthermore, the Azar Declaration <u>provides evidence that Warren, Glass, and the Amoco program merely use static simulation, not dynamic simulation, as the present invention claims</u>

(Response 1) First, Declarant has a vested interest in the outcome. MPEP 716.01(c) III. Secondly, no evidence other than the allegation is provided for either that Amoco program is static or that the current claim is dynamic.

(Argument 2) Applicant has argued in Remarks (8/5/10) Pg.6:

> As described in Glass, Figure 3A shows measurements resulting from a simulation (Glass, col. 5, lines 24-25). Applicant notes that simulations necessarily must occur as time passes. Glass explains that Figure 3A shows a plot of various measured torques for typical PDC bit designs as the bit drills through rock varying in hardness, and inserts showing corresponding cutter damage (Glass, col. 5, lines 24-31). In particular, Glass discloses using an Amoco model1 (also referred to as "Amoco program") to simulate down-hole conditions while simulating drilling through a transition zone of differing compressive strengths and the data from the Amoco model is then plotted graphically to represent the percent torque per cutter distribution under a specified drilling condition. This is exemplified by Figure 3A and its associated text. <u>Thus, Glass is directed to using outputs from the Amoco program to generate torque per cutter distribution graphs, and using those graphs to reduce local maximums in torque on cutter for transitional regions. [1]</u>
>
> Applicant respectfully asserts that it is not possible for Glass, and the use of the Amoco model, to teach or suggest the use of time as a variable, as required in part by the present claims, and this is exemplified in several ways. <u>For example, the modeling method described by the Amoco model only outputs a single numeric answer, such as the volume of rock removed by a cutter, the total weight-on-bit, bit torque, etc. Thus, the Amoco model does not provide a dynamic model or simulation of drilling.</u> **[2]** This is further demonstrated by the fact that the Amoco model does not provide any use of time as a variable, or any suggestion of using time as a variable. Thus, the Amoco model is limited to providing a static model. Therefore, Glass and the Amoco model, do not teach or suggest the use of time as a variable, or the selection of a pre-selected amount of time.

(Response 2) As per [1] Glass also teaches Fig.4A-C modification of bits presented in Fig.3A-B where the torque magnitude is less than the predetermined value for the preselected time (revolutions).

As per [2], This statement is conclusory, and applicant has not shown through specification or claimed subject matter (limitation not in claim) how the applicant's invention is dynamic, only then the comparison can be made that the Amoco program is static, even if so. See additionally Chen is shown to include both the number of revolutions a maximum preselected time.

(Argument 3) Applicant has argued in Remarks (8/5/10) Pg.7:

> In addition, Applicant notes that Figure 3A in Glass (a torque distribution graph) only provides a measurement of torque based on revolutions of a drill bit. In other words, such a torque distribution graph is only concerned with ft-lbs of torque that are applied to a cutting element at a certain point of revolution of the drill bit within a formation. <u>Applicant further notes that time is relative when taking measurements based on the revolution of a drill bit because the amount of time per revolution necessarily depends on the speed of revolution</u>. **[1]** <u>Thus, it is not possible for time to be measured or pre-selected based on the data provided in Figure 3A and its associated text.</u>
>
> Turning to the Examiner's assertion that "Glass teaches the limitation of preselected time" because "Applicant admits.., that time passes during [the] boxed simulation cycle [of Glass]" (see Office Action, pages 2 and 3), Applicant respectfully disagrees. To Applicant's knowledge, there is presently no known method of stopping time. In other words, time is always progressing. Thus, Applicant acknowledges, as asserted by the Examiner, that during any type of simulation, time does indeed pass. <u>However, Applicant maintains that the fact that time does not stop does not teach or suggest selecting a preselected amount of time. Selecting a preselected time necessarily requires performing an action (e.g., preselecting an amount of time) prior to a step that will use the action (e.g., measuring variables during the preselected amount of time). Applicant does not see how preselecting an amount of time could be taught or suggested by the well-known fact that time does not stop, as asserted by the Examiner.</u> Thus, contrary to the Examiner's assertion, there is no teaching or suggestion that the particular timeframe shown in Figure 3A is comparable to a preselected time.

(Response 3) New reference teaches Chen teaches exactly that revolutions and preselected time is used for the simulation. See Chen Fig.1A-C and [0069]. Examiner's position that time passes during simulation is <u>*misinterpreted*</u> as "real time" passes. The time is reference was "simulated time" during which the revolutions in the simulation happen and it stops when the simulation stops. (Please see Response 3 from Action dated 04/05/2010).

The valid point applicant has brought up (see [1]) is revolution/quantum of time is not defined or total amount of time (preselected time) is not defined however new prior art Chen teaches the preselected time.

(Argument 4) Applicant has argued in Remarks Pg.10:

> In addition, the Examiner asserts that "[e]ven is (sic) Ma and Glass are presumed not to explicitly teach outputting a drill bit design on the generated ratio between the WOB... and radial forces.., such suggestion is clearly present in Glass Col.5 Lines 8-24." Applicant respectfully disagrees with Examiner's assertion and notes that col. 5, lines 8-24 in Glass discloses "adjusting cutter size, blade position, bit profile and cutter distribution" and using "tool face control" to effectively apply weight on bit to achieve competitive rates of penetration. This selected text does not teach or suggest outputting a drill bit design based on a generated **ratio between the WOB and radial forces….**

(Response 4) Glass teaches in Col.4 Lines 27-52:

> Given the input of bit Rate Of Penetration, Revolutions Per Minute, Rock Strength, cutter type, cutter location, cutter orientation and bed boundary location. **The program calculates the reactive force per cutter. These cutter forces are then summed to the orthogonal components of the general force system required to drill at the given input parameters**. The orthogonal components are F.sub.x (imbalance), **F.sub.y (weight on bit),** F.sub.z (imbalance), M.sub.x (imbalance), **M.sub.y (torque on bit),** M.sub.z (imbalance). These components are summed at the origin of the bit coordinate system. This coordinate system is attached to the bit as defined by the input cutter location data. Cutter forces are defined by a drag force and a penetrating force. The drag force is assumed to be generated at the cutter tip, in the direction of the cutter velocity and is proportional to the cutter engagement area and back-rake angle. A penetrating force is also calculated that is orthogonal to the drag force and is oriented to a vector as defined by the principle moment of inertia of the engagement area. The penetrating force is also proportional to the engagement area and back-rake angle.
>
> In addition to the above calculations, when the bed boundary is encountered by a cutter, **the force on that cutter is changed in proportion to the change in rock strength and amount of engagement area in the bed boundary. The force on a cutter will change in proportion to the above parameters until it is fully engaged below the bed boundary**.

The rock strength mentioned above changes the proportionality of the forces, two of which are **F.sub.y (weight on bit) and M.sub.y (torque on bit),** where the torque is the radial force. Further, this limitation is taught by Beaton and applicant is performing piecemeal analysis. Applicant has not argued that Beaton does not teach this feature.

(Argument 5) Applicant has argued in Remarks Pg.11:

> Ma and Beaton do not provide that which Glass lacks. There is no teaching or suggestion in Ma or Beaton to adjust at least one parameter of the selected drill bit based on the generated ratio

> until the magnitude of the radial forces is less than a predetermined value for a preselected time for a simulated drilling, as required by the claimed invention. Independent claims 45 and 46 are patentable over Ma, Glass, and Beaton, …

(Response 5) See response 2-3.

(Argument 6) Applicant has argued in Remarks Pg.11:

> Additionally, Applicant respectfully notes that the Office Action appears to be incomplete. For example, on page 6, … See Office Action, page 6. Applicant respectfully requests that the Examiner provide a complete Response to Claim Rejections.

(Response 6) This was side note for examiner's own review. Response 6 on Pg.6 is complete.

(Argument 7) Applicant has argued in Remarks Pg.11-12:

> *In regards to Beaton2…*

(Response 7) No new arguments are presented other than the ones already addressed above.

(Argument 8) Applicant has argued in Remarks Pg.:

> Warren discloses modeling polycrystalline-diamond-compact (PDC) bit designs and modeling the forces required to remove a fixed volume of rock with a single cutter applied to different PDC bit designs. Warren further discloses results of comparing such models to laboratory drilling tests for different bit designs in different rocks to determine whether the model predictions are comparable to the measured data. Warren fails to disclose that which Ma and Glass lack. In fact, Warren suffers from a similar deficiency as Ma, in that it also fails to show or suggest evaluating a bit on the basis of a ratio of radial force to applied weight on bit.

(Response 8) In response to applicant's arguments against the references individually, one cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. See *In re Keller*, 642 F.2d 413, 208 USPQ 871 (CCPA 1981); *In re Merck & Co.,* 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986). Specifically, Beaton is used to teach the limitation evaluating a bit on the basis of a ratio of radial force to applied weight on bit (See Beaton [0034]) as compared to Warren and Ma. Applicant's arguments are therefore not persuasive for at least the reasons above.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

11. **Claims 2-7, 14-23 and 25-38 are and 45-48 are rejected under 35 U.S.C. 103(a) as being unpatentable over "The Operational Mechanics of The Rock Bit", Ma et al, Petroleum Industry Press, Copyright 1996, further in view of U.S. Patent 6695073 issued to Glass et al, further in view of US PGPUB 20010020552 A1 by Beaton et al,** further in view of USPGPUB 2003/0051918 by Chen et al.

The Ma reference is a study of the dynamics of the interaction between the roller cone drill bit and rock (earth) including bit geometry, kinematics, axial loading, and the balancing (equalization) of forces acting on a roller cone drill bit. In particular, Chapter 6, and to some degree Chapter 5, of Ma sets forth the elements of what he refers to as the "New Methodology" for roller cone bit design. This "New Methodology" includes the use of drilling simulation and computer modeling for optimizing the parameters relating to the design of new roller cone drill bits. (See: page 1, paragraph 2, for condensed overview).

The examiner submits that the teachings of Ma render obvious the claimed limitations of the instant invention as presently claimed as follows:

Regarding independent claim 45: *A method for designing a drill bit, comprising:*

- determining radial forces acting on a selected drill bit during simulated drilling; (6.1, 6.1.2.3, 5.3, 3.3 - 3.5, Ma discloses drilling simulation, forces acting on roller cones

at least at pages 128, 129, section 5.1)

- evaluating the radial forces based on at least one selected criterion; (Ma teaches forces acting on roller cones at least at pages 128, 129, section 5.1, which would be an inherent part of optimizing the 3-D load model using finite element analysis disclosed in sections 6.1-6.2.3 of Ma. (especially, 6.1.1.5))

- wherein evaluating comprises summing magnitudes of the radial forces with respect to a direction to, generate a sum of the radial forces is a limitation not explicitly taught by Ma and is taught by Glass (Glass: Col.4 Lines 27-56)*;*

- comparing the sum of the radial forces to an applied weight-on-bit is a limitation not explicitly taught by Ma and is taught by Glass (Glass: Col.4 Lines 47-56)*; and*

- generating a ratio between the sum of the radial forces and the applied weight-on-bit is a limitation not explicitly taught by Ma and is taught by Glass (Glass: Col.4 Lines 47-56);

- adjusting at least one parameter of the selected drill bit based on the evaluating; (Ma: 6.1, 6.1.1.1, 6.1.2.3, page 232, lines 6-11, Ma sets forth adjusting design parameters; Glass: Col.4 Line 58-Col.5 Line 11) and more specifically, ***"adjusting at least one parameter of the selected drill bit based on the generated ratio until the magnitude of the radial forces is less than a predetermined value"*** (Glass: Fig3A - where the torque is expressed as the percentage less than certain amount associated with the radial forces*; Also See Glass Col.5 Lines 24-34)* ***for a pre-selected time*** (Glass: Fig.3A pre-selected simulation time represented by pre-selected simulated revolutions 1-117 for example), ***for a simulated drilling*** (Glass: Fig.1 Step 110).

It would have been obvious to a skilled artisan having access to the teachings Ma at the time of the invention to combine Ma and Glass as both of them are directed towards modeling the drill bit and computing forces which is also a deficiency in Ma explicitly taught by Glass disclosing programmed calculations of summed orthogonal cutter forces inclusive of weight-on-bit. (CL4-L27-46). Further the motivation to combine is defined by the current state of the prior art - i.e. teaching of Glass where it admits the force distribution can be optimized for either roller cone or PDC drill bit the similar way (Glass Col.7 Lines 11-14).

Glass teaches adjusting at least one parameter (Glass Col.5 Lines 8-24) of the selected drill bit based on the generated ratio (WOB and Torque) and outputting a drill bit design based on the generated ratio and the adjusting.

Even if Ma and Glass are presumed not to explicitly teach outputting a drill bit design based on the generated ratio between the WOB (Fy component in Glass) and radial forces (Fx and Fz force components in Glass) to modify, such suggestion is clearly present in Glass Col.5 Lines 8-24 & Col.4 Lines 27-52.

Beaton explicitly teaches outputting a drill bit design based on the generated ratio between the WOB in [0035] as:

> [0034] **In another aspect of the invention, it has been determined that the drilling stability of a bi-center bit can be further improved by force balancing the entire bit 10 as a single structure**. Force balancing is described, for example, in, T. M. Warren et al, Drag Bit Performance Modeling, paper no. 15617, Society of Petroleum Engineers, Richardson, Tex., 1986. Prior art bi-center bits were force balanced, but in a different way. **In this embodiment of the invention the forces exerted by each PDC cutters 12 can be calculated individually, and the locations of the blades and the PDC cutter 12 thereon can be selected so that the sum of all the forces exerted by each of the cutters 12 will have a net imbalance of less than about 10 percent of the total axial force exerted on the bit (known in the art as the "weight on bit").** The designs of both the pilot section 13 and the reaming section 15 are optimized simultaneously in this aspect of the invention to result in the preferred force balance. **An improvement to drilling stability can result from force balancing according to this aspect of the invention because the directional components of the forces exerted by each individual cutter 12 are accounted for.** In the prior art, some directional force components, which although summed to the net lateral force exerted individually by the reaming section and pilot section, can result in large unexpected side forces when the individual cutter forces are

summed in the aggregate in one section of the bit to offset the aggregate force exerted by the other section of the bit. **This aspect of the invention avoids this potential problem of large unexpected side forces by providing that the locations of and shapes of the blades 14, 1 and cutters 12 are such that the sum of the forces exerted by all of the PDC cutters 12, irrespective of whether they are in the pilot section 13 or in the reaming section 15, is less than about 10 percent of the weight on bit.** It has been determined that still further improvement to the performance of the bit 10 can be obtained by balancing the forces to within 5 percent of the axial force on the bit 10.

It would have been obvious to a skilled artisan having access to the teachings Ma at the time of the invention to combine Beaton and Glass as Beaton cures the recognized deficiency in Glass of force balancing the entire PDC drill bit (Beaton: [0034]; Glass: Col.5 Lines 8-24) thereby increasing the stability of bi-center drill bit.

For argument sake that Ma, Glass and Beaton does not explicitly teach a **preselected time**.

Chen teaches preselected time as **maximum time step**, delta - in Chen [0069], which is preselected as input to the simulation.

[0069] Next the bit mechanics are calculated. (See FIG. 1C.) Again transformation matrices from cone to bit coordinates are calculated (step 128), and the **number of bit revolutions and maximum time steps, delta, are input (step 130).** The cones are then counted (step 132), the bit and cone rotation angles are calculated at the given time step (step 134), and the rows are counted (step 136). Next, the 3D tooth surface matrices for the teeth on a given row are calculated (step 138). The teeth are then counted (step 140), and the 3D position of the tooth on the hole bottom is calculated at the given time interval (step 142). If a tooth is not cutting, counting continues until
a cutting tooth is reached (step 144). The cutting depth, area, volume and forces for each tooth are calculated, and the hole bottom model is updated (based on the crater model for the type of rock being drilled). Next the number of teeth cutting at any given time step is counted. The tooth force is projected into cone and bit coordinates, yielding the total cone and bit forces and moments. Finally the specific energy of the bit is calculated (step 146).

It would have been obvious to a skilled artisan having access to the teachings Ma at the time of the invention to combine Chen and Ma as Chen cures the recognized deficiency in Ma of *providing the advantage of* ***quick feedback to design engineer*** thereby permitting the designer to optimally select different types of teeth for different rows (of a drill bit) based on tooth trajectory (Chen: [0037]-

[0043]).

<u>Regarding independent claim 46</u>: *A method for designing a bottom hole assembly, comprising:*

- determining radial forces acting on a bottom hole assembly during simulated drilling, said bottom hole assembly including a drill bit. (6.1, 6.1.2.3, 5.3, 3.3 - 3.5, Ma discloses drilling simulation, forces acting on roller cones at least at pages 128, 129, section 5.1, and a bottom pattern modeling at least in Figures 5-20 to 5-32)

- evaluating the radial forces based on at least one selected criterion; (Ma teaches forces acting on roller cones at least at pages 128, 129, section 5.1, which would be an inherent part of optimizing the 3-D load model using finite element analysis disclosed in sections 6.1-6.2.3 of Ma. (especially, 6.1.1.5))

- wherein evaluating comprises summing magnitudes of the radial forces with respect to a direction to, generate a sum of the radial forces is a limitation not explicitly taught by Ma and is taught by Glass (Glass: Col.4 Lines 27-56)*;*

- comparing the sum of the radial forces to an applied weight-on-bit is a limitation not explicitly taught by Ma and is taught by Glass (Glass: Col.4 Lines 47-56)*; and*

- generating a ratio between the sum of the radial forces and the applied weight-on-bit is a limitation not explicitly taught by Ma and is taught by Glass (Glass: Col.4 Lines 47-56);

- adjusting at least one parameter of the bottom hole assembly based on the evaluation (6.1, 6.1.1.1, 6.1.2.3, page 232, lines 6-11, Ma sets forth adjusting design parameters *Glass: Col.4 Line 58-Col.5 Line 11) and more specifically,* ***"adjusting at least one parameter of the selected drill bit based on the generated ratio until the magnitude of the radial forces is less than a predetermined value"*** (Glass: Fig3A -

where the torque is expressed as the percentage less than certain amount associated with the radial forces*; Also See Glass Col.5 Lines 24-34*) ***for a pre-selected time*** (Glass: Fig.3A pre-selected simulation time represented by pre-selected simulated revolutions 1-117 for example), ***for a simulated drilling*** (Glass: Fig.1 Step 110).

Hence, it would have been obvious to a skilled artisan having access to the teachings Ma at the time of the invention to realize the elements of the present invention as currently claimed. An obvious motivation exists since Ma teaches that the elements as claimed, and noted above, can be combined in order to find an optimum design and avoid bit (breakage) failure (chapter 6, section 5.4, especially page 232, based on the entire teaching).

It would have been obvious to a skilled artisan having access to the teachings Ma at the time of the invention to combine Ma and Glass as both of them are directed towards modeling the drill bit and computing forces which is also a deficiency in Ma explicitly taught by Glass disclosing programmed calculations of summed orthogonal cutter forces inclusive of weight-on-bit. (CL4-L27-46). Further, the motivation to combine is defined by the current state of the prior art - i.e. teaching of Glass where it admits the force distribution can be optimized for either roller cone or PDC drill bit the similar way (Glass Col.7 Lines 11-14).

Glass teaches adjusting at least one parameter (Glass Col.5 Lines 8-24) of the selected drill bit based on the generated ratio (WOB and Torque) and outputting a drill bit design based on the generated ratio and the adjusting.

Even if Ma and Glass are presumed not to explicitly teach outputting a drill bit design based on the generated ratio between the WOB (Fy component in Glass)

and radial forces (Fx and Fz force components in Glass) to modify, such suggestion is clearly present in Glass Col.5 Lines 8-24 and Col.4 Lines 27-52.

Beaton explicitly teaches outputting a drill bit design based on the generated ratio between the WOB in [0035] as:

> [0034] **In another aspect of the invention, it has been determined that the drilling stability of a bi-center bit can be further improved by force balancing the entire bit 10 as a single structure**. Force balancing is described, for example, in, T. M. Warren et al, Drag Bit Performance Modeling, paper no. 15617, Society of Petroleum Engineers, Richardson, Tex., 1986. Prior art bi-center bits were force balanced, but in a different way. **In this embodiment of the invention the forces exerted by each PDC cutters 12 can be calculated individually, and the locations of the blades and the PDC cutter 12 thereon can be selected so that the sum of all the forces exerted by each of the cutters 12 will have a net imbalance of less than about 10 percent of the total axial force exerted on the bit (known in the art as the "weight on bit").** The designs of both the pilot section 13 and the reaming section 15 are optimized simultaneously in this aspect of the invention to result in the preferred force balance. **An improvement to drilling stability can result from force balancing according to this aspect of the invention because the directional components of the forces exerted by each individual cutter 12 are accounted for.** In the prior art, some directional force components, which although summed to the net lateral force exerted individually by the reaming section and pilot section, can result in large unexpected side forces when the individual cutter forces are summed in the aggregate in one section of the bit to offset the aggregate force exerted by the other section of the bit. **This aspect of the invention avoids this potential problem of large unexpected side forces by providing that the locations of and shapes of the blades 14, 1 and cutters 12 are such that the sum of the forces exerted by all of the PDC cutters 12, irrespective of whether they are in the pilot section 13 or in the reaming section 15, is less than about 10 percent of the weight on bit.** It has been determined that still further improvement to the performance of the bit 10 can be obtained by balancing the forces to within 5 percent of the axial force on the bit 10.

It would have been obvious to a skilled artisan having access to the teachings Ma at the time of the invention to combine Beaton and Glass as Beaton cures the recognized deficiency in Glass of force balancing the entire PDC drill bit (Beaton: [0034]; Glass: Col.5 Lines 8-24) thereby increasing the stability of bi-center drill bit.

For argument sake that Ma, Glass and Beaton does not explicitly teach a **preselected time**.

Chen teaches preselected time as **maximum time step**, delta - in Chen [0069], which is preselected as input to the simulation.

> [0069] Next the bit mechanics are calculated. (See FIG. 1C.) Again transformation matrices from cone to bit coordinates are calculated (step 128), and the **number of bit revolutions and maximum time steps, delta, are input (step 130).** The cones are then counted (step 132), the bit and cone rotation angles are calculated at the given time step (step 134), and the rows are counted (step 136). Next, the 3D tooth surface matrices for the teeth on a given row are calculated (step 138). The teeth are then counted (step 140), and the 3D position of the tooth on the hole bottom is calculated at the given time interval (step 142). If a tooth is not cutting, counting continues until
> a cutting tooth is reached (step 144). The cutting depth, area, volume and forces for each tooth are calculated, and the hole bottom model is updated (based on the crater model for the type of rock being drilled). Next the number of teeth cutting at any given time step is counted. The tooth force is projected into cone and bit coordinates, yielding the total cone and bit forces and moments. Finally the specific energy of the bit is calculated (step 146).

It would have been obvious to a skilled artisan having access to the teachings Ma at the time of the invention to combine Chen and Ma as Chen cures the recognized deficiency in Ma of *providing the advantage of* ***quick feedback to design engineer*** thereby permitting the designer to optimally select different types of teeth for different rows (of a drill bit) based on tooth trajectory (Chen: [0037]-[0043]).

Per claims 2-7*: Ma renders obvious elements relating to performance parameters and cutting element interaction of a roller cone bit as noted above (6.1, 6.1.1.1, 6.1.2.3, page 232, lines 6-11)*

Per claims 12-13

Beaton teaches the ratio of the sum of the radial forces to the applied weight on bit is less than or equal to 0.10 or 0.05 (Beaton: [0034]).

Per claims 14-23 and 26-35*: The recited box-whisker plot is simply a well-known convenient way of graphically depicting a number summary, which consists of the smallest observation, lower quartile, median, upper quartile, and largest observation (See: CRC, or Wikipedia, for example) and hence would have knowingly been implemented by a skilled artisan in order to graphically depict the summed forces.*

Per claims 36-38: *Ma teaches adjusting bit design parameter (Section 6.1.2.3) and bit parameters (Ma: Chapter 2).*

12. **Claim 11 rejected under 35 U.S.C. 103(a) as being unpatentable under Ma, in view of Glass, further in view of Beaton, further in view of Chen, further view of US. Patent 6039131 issued to Beaton (Beaton2 hereafter).**

Regarding Claim 11

Teachings of Ma, Glass and Beaton are shown in the parent claim 45.

Ma, Glass and Beaton do not explicitly teach the ratio of the sum of the radial forces to the applied weight on bit is less than or equal to 0.20.

Beaton2 teaches the ratio of the sum of the radial forces to the applied weight on bit is less than or equal to 0.20 (Beaton2: Col.3 Lines 7-11).

Hence a skilled artisan would have knowingly modified the teachings of Beaton2 with the teachings of Beaton as Beaton2 is Beaton's own work in an analogous field of PDC drill bit design.

Motivation to combine under Ma, in view of Glass, further in view of Beaton, further in view of Chen is same as provided in the parent claim 45.q

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13. **Claims 8 and 9 are rejected under 35 U.S.C. 103(a) as being unpatentable under Ma, in view of Glass, further in view of Beaton, further in view of Chen, in further view of "Drag-Bit Performance Modeling, Warren et al, SPE Drilling Engineering, June 1989"**

Analogous art Warren renders obvious elements of the present invention relating to simulating the fixed cutter drill bit drilling an earth formation; (pp. 119, col. 1, para:3-7, pp. 126, col. 1, para:2 to col. 2, para:3, Fig. 6) and determining a cutter-formation interaction force, relative sliding velocity, and cutting surface parameters on a cutter of the fixed cutter drill bit (pp. 19, col. 1, para:6, 7, pp. 126, col. 1, para:2 to col. 2, para:3, Fig. 6, Fig. 6).

Motivation to combine Ma with Glass is presented in the parent claim 45.

Motivation to combine Beaton with Glass is presented in the parent claim 45.

Motivation to combine Chen with Ma is presented in the parent claim 45.

Hence a skilled artisan would have knowingly modified the teachings of Ma with the teachings of Warren, motivated using the same reasoning as previously cited above, to model and implement a fixed cutter drill bit. Ma teaches simulation and computation of forces acting on the drill bit (Ma: Section 5.3 "Simulation Test of the crater forming process by bit teeth" and at least on Pg.202 – as shown on previous page). Ma acknowledges that computer aided simulation and display is anticipated (Ma: Pg.207) analogous to the teaching of Warren (Warren: *pp. 126, col. 1, para:2 to col. 2, para:3, Fig. 6, Fig. 6*) and Glass (Glass: *Col.4 Line 58-Col.5 Line 11*).

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Communication

Any inquiry concerning this communication or earlier communications from the examiner should be directed to AKASH SAXENA whose telephone number is (571)272-8351. The examiner can normally be reached on 8:00- 6:00 PM Mon-Thu.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kamini S. Shah can be reached on (571)272-2279. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

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